How the practice of clustering shapes cluster emergence

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ABSTRACT

How successful clusters emerge remains unclear. In this paper, we investigated how the exercise of system-level agency contributes to cluster emergence. We applied a practice perspective and found that system-level agency is enabled by the 'practice of clustering': a recurring set of coordinated and future-oriented activities through which regional actors collectively attempt to restructure the regional context to better support cluster emergence. The findings suggest that the specific practice of clustering that takes root in a given region helps explain why some nascent agglomerations develop into a functioning and viable cluster, while others do not.

Keywords: Industry clusters; emergence; path creation; practice theory; biotechnology

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INTRODUCTION

The puzzle of cluster emergence centres on how nascent industry agglomerations evolve into the 'critical mass' of companies and institutions characteristic of functioning clusters (Fornahl et al, 2010). Nascent industry agglomerations are constituted by a few, mostly small firms and other organisations within a particular field in a particular location that have potential for cluster formation[i], but lack the interconnections[ii] and systemic effects of a fully-fledged cluster (Menzel & Fornahl, 2010). Clarifying the processes through which latent clusters become actual clusters is an increasingly important area of research in regional studies (e.g. Braunerhjelm & Feldman, 2008; Menzel & Fornahl, 2010; Boschma & Fornahl, 2011; Trippl et al 2015; Henn & Bathelt, 2017), and is essential if we are to explain why some nascent agglomerations develop into viable clusters, while others do not.

Existing research has shed light on key dimensions of cluster emergence, including initiating factors, processual dynamics, and regional embeddedness. Studies focusing on *initiating factors* observe that the factors driving cluster emergence are distinct from those driving cluster function (Bresnahan et al 2001), but do not explain why clusters may fail to emerge even when key initiating factors are in place. Studies focusing on *processual dynamics* – i.e. models of how clusters emerge, grow, mature, are renewed, or decline (Menzel & Fornahl 2010; Ter Wal & Boschma, 2011) – reveal that cluster emergence is driven by entrepreneurship, network development, and various self-reinforcing mechanisms. Yet, this work does not sufficiently address how the place-specific conditions and legacies of regions influence cluster dynamics (Trippl et al, 2015).

Finally, research emphasising *regional-embeddedness* frames cluster emergence as a form of industrial path creation (Fornahl et al 2010; Nefke et al, 2011). Recent conceptual work (MacKinnon et al, 2019; Hassink et al, 2019) argues that human agency plays a pivotal, but

underappreciated, role in the path creation processes enabling cluster emergence. It distinguishes between agency exercised at the 'firm-level' (which animates entrepreneurial start-up and spin-off processes as well as innovation within firms), and agency exercised at the 'system-level' (which animates coordinated actions by multiple firm and non-firm[iii] actors to intentionally restructure the regional context to better support new paths) (Hassink et al, 2019). To date, firm-level agency has been privileged over system-level agency in explaining how new clusters arise in regions. Accordingly, there is scant empirical insight into a) how regional actors of various kinds actually exercise system-level agency in pursuit of cluster development and b) how the outcomes of such efforts contribute to the path creation processes enabling cluster emergence (Grillitsch & Sotarauta, 2018; MacKinnon et al, 2019).

In this paper, we investigate how regional actors exercise system-level agency in order to build and maintain a cluster, and what contribution this makes to cluster emergence. Existing work suggests that the exercise of system-level agency is a reflexive, multi-actor, multi-scalar, and institutionally-structured process (Hassink et al, 2019). We thus adopt a practice theoretical perspective (Schatzki et al, 2001; Jones & Murphy, 2011) that directs attention to the actors, activities, and understandings through which system-level agency is exercised, but that also remains sensitive to how it is shaped by the historical legacies and resource base of a region. A practice perspective conceptualises system-level agency as exercised by regional actors through the *'practice of clustering'*: that is, a specific social practice consisting of a recurring set of coordinated and future-oriented activities through which regional actors from different social spheres (e.g. industry, academe, government, finance) seek to restructure the regional context to better support cluster emergence. It entails a) enabling cluster visions, strategies, and interventions across organisational, sectoral, and institutional boundaries; and 2) mobilising various regional actors and communities to participate in, and benefit from, collective efforts to build and maintain a cluster.

We examine how the practice of clustering shaped the emergence of two nascent biotechnology clusters. Our findings make three main contributions to the literature on cluster emergence, particularly with regards to the mechanisms of path creation and institutionalisation enabling this process. First, we identify and elaborate how the 'practice of clustering' provides a basis for regional actors to build, develop, and maintain a cluster. Our novel model of the 'practice of clustering' sheds new light on the mechanisms of cluster emergence by revealing how regional actors' concerted efforts to (re)structure the institutional and organisational setup of regions contributes to making cluster emergence more or less likely. Second, we show that practice of clustering is constituted by four activities – *catalysing, coordinating, configuring,* and *deliberating* – organised and integrated by development of a shared understanding of a) an envisioned cluster future and b) how to work and act together to achieve this. Finally, we show that some ways of practicing clustering better supports cluster emergence than others, which subsequently helps explain why some nascent agglomerations develop into functioning and viable clusters, while others do not.

EXISTING RESEARCH ON CLUSTER EMERGENCE

Interest in how budding agglomerations become functioning clusters has increased significantly in recent years (e.g. Feldman & Braunerhjelm, 2006; Boschma & Fornahl, 2011; Trippl et al 2015), but it is possible to distinguish three main foci: *initiating factors, processual dynamics,* and *regional embeddedness.*

First, a major focus has been on *initiating factors* for cluster emergence, gleaned largely from historical case analyses (see Brenner & Mühlig, 2013 for a meta-review). This "list of ingredients" (Feldman & Braunerhjelm, 2006) approach has identified the requisite conditions (e.g. local demand, skilled labour, a strong scientific base, entrepreneurial culture), triggers (e.g. chance events, government policy), and reinforcing mechanisms (e.g. resource

accumulation, learning, agglomeration economies) important in the birth and growth of clusters (Brenner & Mühlig, 2013). It has also revealed that the factors important cluster creation are distinct from those important in its function, being largely focused on firm-building capabilities, managerial skills, skilled labour supply, and market access (Bresnahan et al, 2001). A limitation of this approach is that it assumes the mere presence of initiating factors is sufficient for cluster emergence, which may not be the case as initially promising agglomerations often fail to reach critical mass.

A second area of research examines the *processual dynamics* of cluster emergence, growth, maturity, renewal, and/or decline. Various approaches can be loosely grouped here, including clusters as regional manifestations of industry lifecycles (Pouder & St. John, 1996), as evolutionary cycles (Menzel & Fornahl, 2010; Ter Wal & Boschma, 2011), as complex self-organising systems (Feldman et al, 2005), or the relational outcome of 'buzz-and-pipeline' knowledge flows (Henn & Bathelt, 2017). Although these approaches differ in their nuances, including underlying theoretical perspective and ratio of determinism or contingency (Boschma & Fornahl, 2011), they all underscore that cluster emergence depends critically on entrepreneurial start-up and spin-off processes. Similarly essential are network building processes that gradually enmesh firms in a dense local web of information and insight, while also fostering (re)generative translocal knowledge flows. These approaches reiterate the significance of reinforcing mechanisms (e.g. increasing returns, interactive learning). Despite this, these approaches do not fully explain why it is some nascent agglomerations tip towards growth and others towards stagnation. Part of the problem here is (to varying degrees) insufficient attention[iv] to how processual dynamics are shaped by the regional contexts in which they are embedded (see Trippl et al, 2015 for elaborated critique).

Finally, a third area of research foregrounds *regional-embeddedness* by examining cluster emergence as a regional 'path creation' process (Karnøe & Garud, 2012; MacKinnon

et al, 2019; Hassink et al, 2019). Regional path creation refers "to the emergence and growth of new industries and economic activities in regions" (MacKinnon et al, 2019:114). Existing studies indicate new clusters often branch out from pre-existing technologically related industries in a region (Nefke et al, 2011). Thus, the legacies of a region's past, including its endowment of resources (e.g. skills, investment capital, research facilities, and supporting institutions), conditions the possibilities for new paths – and hence new clusters – to emerge.

A developing strand of this literature further suggests that path creation relies critically on human agency[v]: "*knowledgeable actors, operating within multiscalar institutional environments, create new paths through the strategic coupling of regional and extraregional assets to mechanisms of path creation"* (MacKinnon et al, 2019:1). The basic claim is that agency mediates the interplay between pre-existing regional structures and evolving selection forces, helping explain why path-dependent cluster development processes vary even if the same initiating conditions are in play (Sydow et al, 2010).

Agency features in path creation at two different levels: firm-level and system-level (Isaksen, 2019; Hassink et al, 2019). 'Firm-level' agency is exercised by industry actors who initiate new firms or innovation activities in existing firms (Isaksen et al, 2019). Its main sphere of influence is within one firm or organisation (Hassink et al, 2019). The significance of firm-level agency is well established in existing accounts of cluster emergence, especially those taking their point of departure from an evolutionary economic perspective (e.g. emphasising firm-level routines and learning, and the criticality of start-up and spin-off processes).

System-level agency, in comparison, refers to regional actors seeking to influence across organisational and institutional boundaries. The exercise of agency at the 'system-level' entails collective and coordinated actions by multiple kinds of regional actors (e.g. from industry, government, research institutes, universities, intermediaries) to intentionally transform the regional context to support the path creation processes enabling cluster

emergence (Isaksen et al, 2019; Hassink et al, 2019). While not labelled as such, this is agency of the kind implicated in recent studies of network coordination in an emerging German optics cluster (Sydow et al., 2010) and of the institutional entrepreneurship of leading scientists to create a Finish functional foods cluster (Ritvala & Kleyman, 2012).

To date, there has been scant empirical investigation into how the exercise of system-level agency by regional actors influences the path creation processes enabling cluster emergence (Holmen & Fosse, 2017; Isaksen et al 2019; MacKinnon et al, 2019; Hassink et al, 2019). Accordingly, understanding of its function and import in cluster emergence is limited. It is also unclear how system-level agency is made possible in nascent agglomerations. Nascent agglomerations are often "institutionally thin" (Amin & Thrift, 1994; Beer & Lester, 2015; Zukauskaite et al, 2017), consisting of an atomistic assortment of a few firms and other organizations, and an absent (or only partially shared) sense of a collective 'cluster' and common goals and strategy for its development. Material resource scarcity and a "hostile social environment" may constrain reflexivity and cooperation (Staber, 2011: 1351). Given these constraints, how are the interactions and relationships necessary for the exercise of system-level agency first forged in nascent agglomerations? How are different ways of cooperating and coordinating developed and instituted? What role does local- and trans-local learning play? How are resources marshalled and deployed as part of this? By whom and what means? And how does the existing regional set-up shape these processes? It is to answering these questions we now turn.

A PRACTICE THEORETICAL PERSPECTIVE ON THE ROLE OF SYSTEM-LEVEL AGENCY IN CLUSTER EMERGENCE

We seek to investigate how regional actors exercise system-level agency to build and maintain cluster, and what contribution this makes to cluster emergence. Investigating how regional

actors exercise system-level agency requires attention to the reflexive, multi-actor, multi-scalar, and institutionally-structured nature of this process (Hassink et al, 2019; MacKinnon et al, 2019). In line with recent thinking amongst economic geographers (Jones & Murphy, 2011), we propose a practice theoretical perspective (Schatzki et al, 2001; Nicolini, 2013) offers the conceptual and methodological flexibility to accommodate these different aspects of the phenomenon. A defining feature of the practice perspective is its relational ontology, stipulating that entities such as subject and object and agency and structure are not separate (i.e. independent of each other) but entwined in social practices and their performance (Sandberg & Dall'Alba, 2009). It is through the performance of social practices that structure and agency come together to create, reproduce, and/or transform social systems in intended and unintended ways (Giddens, 1984).

Social practices are sets of routinised activities in a given area of human activity "organised around a shared, practical understanding or 'way of doing'" (Bjørkeng et al., 2009:146). Building on this, the exercise of system-level agency in support of cluster development can be seen as entailing a recurring set of coordinated and future-oriented activities performed by different kinds of regional actors (e.g. from industry, academe, government, finance) that seeks to (re)structure the regional context in order to build, develop, and maintain a cluster. By restructure the regional context we mean to make the regional endowment of skills, resources, social relations, and institutions more favourable to the development and sustainment of a cluster. We use the notion of the '*practice of clustering'* to identify and articulate how regional actors, through their performance of this recurring set of activities, produce and reproduce a cluster.

In framing the practice of clustering as a set of recurring activities performed by regional actors, we build on existing practice perspectives in economic geography (Jones & Murphy, 2011). We do this by foregrounding the actors, activities, and understandings that

constitute the practice of clustering, while simultaneously remaining attentive to how performance of this practice is structured by the regional context in which it is situated. More concretely, by taking the 'practice of clustering' as the unit of analysis we aim to identify who does it; what they do; how is this structured by the existing regional setup; and what outcomes its performance generates.

In examining 'who', we seek to identify the complement of regional actors who exercise system-level agency through the practice of clustering. We adopt a multi-actor approach sensitive to the reflexive and knowledgeable agency of individuals, organizations (e.g. firms, universities and research institutes, government agencies, industry associations), and communities (e.g. the research community, the industry community). In the case of organizations and communities, human actors act on behalf of these collectives in order to 'make things happen' in pursuit of cluster development (Sydow et al., 2010).

In examining 'what', we aim to identify "the routinised set of activities organised around a shared, practical understanding" (Bjørkeng et al., 2009:146) through which regional actors attempt to restructure the regional context to better support cluster emergence. We are conscious of the multi-scalar nature of these activities, i.e. their potential to occur across organisational and institutional boundaries. We are also attuned to their necessarily collective nature: to effect change towards cluster development, regional actors must monitor the simultaneous effects of their own and others' activities, coordinate their actions with others, form collective projects, and persuade (or even coerce) others to engage in joint action (Sewell, 1992).

In examining 'how' these collective activities unfold, we are cognisant of their institutionally-structured nature. Here, the concept of 'institutional thickness' (Amin & Thrift, 1994) can be reinterpreted as entailing inter-subjectively shared sets of rules and resources that pattern actors' activities and interactions (Giddens, 1984). Shared 'rules' include a common

understanding about the nascent agglomeration's agenda, membership, and norms for working and acting collectively, while 'resources' entail authority relations and material resources. In an institutionally 'thin' nascent agglomeration, these shared rules and resources may be absent or only partially-developed, and thus must developed and institutionalised as part of cluster emergence.

Finally, in examining the 'outcomes' of clustering, we recognise that these are only partially within the control of regional actors (Giddens, 1984). Accordingly, the practice of clustering can generate both intended and unintended consequences that together shape the ongoing cluster path, making its 'take-off' or stagnation either more or less likely.

RESEARCH DESIGN

We utilised a historical case study design, focusing on two nascent biotechnology agglomerations located in Brisbane and Melbourne, Australia, from 1998-2009[vi]. Over this period, actors within both regions engaged in sustained efforts to foster biotechnology cluster development, meaning the practice of clustering and its outcomes were likely to be transparently observable.

Data collection and analysis

As detailed in Appendix A and B, data sources included archival materials (n=~350), historical interviews (n=11), and real-time interviews (n=45). Data analysis combined narrative and temporal bracketing strategies (Langley, 1999). The narrative strategy involved construction of detailed case histories from the raw data, while temporal bracketing decomposed the histories into sequential time periods to analyse how regional actors attempted to reconfigure the regional context to better support cluster emergence. Appendix C details the procedures used to identify the actors, activities, understandings, rules, and resources constituting the practice of clustering in each locale, and their implications for cluster emergence.

FINDINGS: THE PRACTICE OF CLUSTERING IN BIOTECHNOLOGY

To provide a framework for explaining the cases, we first present the model of the practice of clustering derived from our analysis. Importantly, the model was not elaborated before our analysis, but rather emerged from it. We however present the model first for two reasons: 1) it makes it easier to grasp and follow the findings, and 2) it helps 'bring the model to life'. We then introduce the Brisbane and Melbourne cases, revealing the different development paths of each agglomeration. Finally, we explain why their development paths differed, linking this to the distinctive practice of clustering observed in each locale.

Revealing the 'practice of clustering'

Figure 1 (below) depicts how system-level agency is exercised by regional actors in pursuit of cluster development through the practice of clustering, namely: 'reflexive actors' (bottom of Figure 1) create and/or draw on 'cluster rules and resources' (top of Figure 1) to engage in the core activities of 'Catalysing', 'Coordinating', 'Configuring' and 'Deliberating', the performance of which aims to reconfigure the regional context to better support cluster emergence over time.

'Catalysing' involves regional actors mobilising collective action to support cluster development. Typically, it involves the skilful action of politically influential actors able to a) build a common interest in developing and sustaining a cluster, and b) identify and frame emergent problems and opportunities as critical in realising this interest. Issue framing, in turn, enables the brokering of relationships, and mobilisation of resources for cluster development (Ritvala & Kleymann, 2012).

'Coordinating' involves the planning and synchronisation of collective action. Here local actors engage in deeper reflection on current ways of doing things and develop consensus as to the over-arching vision, strategy, and priorities for cluster development. Coordinating is

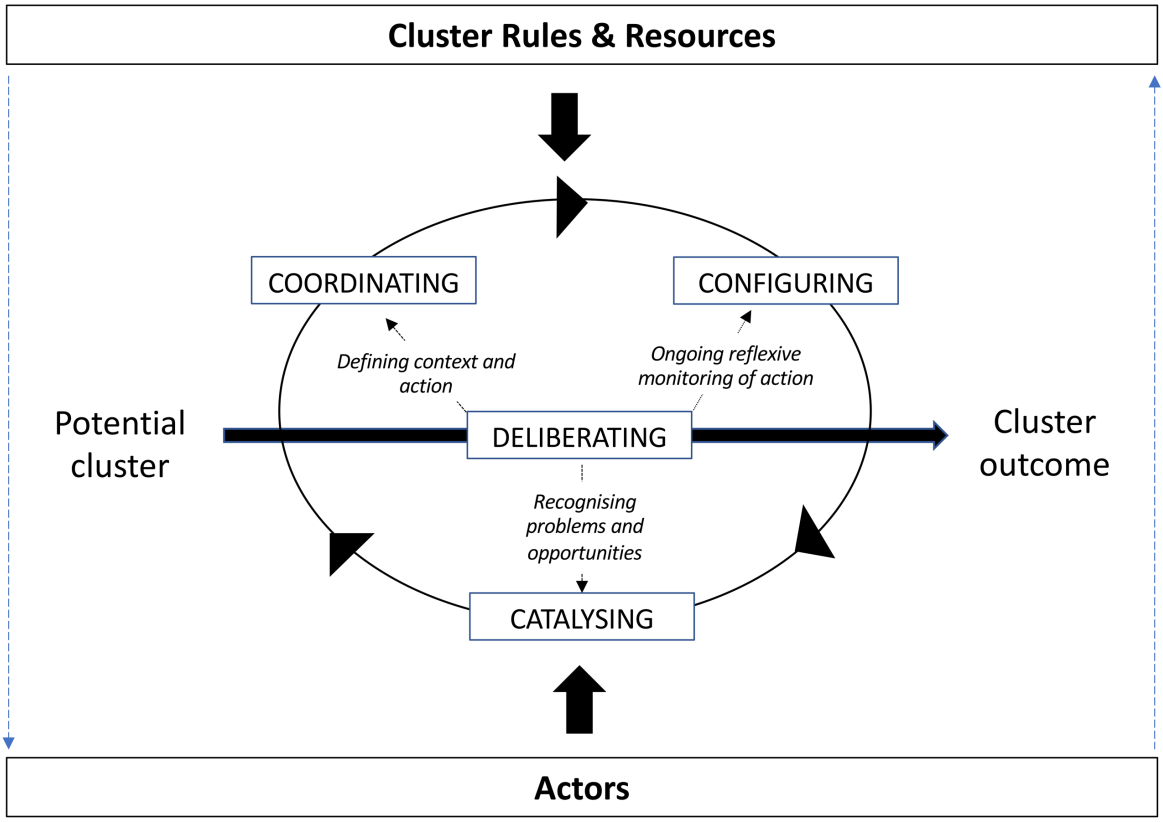
facilitated via three main mechanisms: developing shared understanding of the current context and imagined futures through events and reporting; creating direction through plans and strategies; and maintaining direction via institution of formal organising structures.

'Configuring' refers to the deliberate, tactical interventions by local actors to reconfigure the local context to better support cluster development. These entail specific actions to create new material or financial resources, or to bolster existing ones; to build relationships between actors; or to cultivate/reinforce collective norms, values, and understandings believed to be important to cluster development.

'Deliberating', at the core of the practice of clustering, reflects the innate reflexive capacity of human agents, and is what energises catalysing, coordinating, and configuring. Deliberating provides the basis for local actors to recognise shared problems and opportunities for cluster development; it underpins the deeper critical reflection of the local context, the envisioned future, and the strategic interventions required to achieve this; and it drives reflexive monitoring of the intended and unintended outcomes of clustering activities.

Finally, 'cluster rules and resources' are both the medium and outcome of the practice of clustering; they stand in recursive relation to regional actors and clustering activities. Cluster resources include the material artefacts, financial resources, and authority relations through which power is exercised. Cluster rules entail a shared understanding of clustering that clarifies a common cluster vision and goals, membership, and norms for working and acting together. It is this shared understanding of clustering that organises the four core clustering activities into a specific practice of clustering. In nascent agglomerations, cluster rules and resources may not exist, or be only partially-developed, and hence have to be created and institutionalised through the practice of clustering. However, once developed, these rules and resources structure the ongoing performance of clustering activities by regional actors, making some courses of action either more or less likely.

Figure 1: The practice of clustering



Overview of the cases

As illustrated in Appendices D and E, in the late 1990s, neither Brisbane or Melbourne hosted flourishing biotechnology clusters. Although Melbourne had greater research and industry activity, the two locales displayed many similarities. For instance, while each had capable universities and research centres, both lacked the culture of entrepreneurship, the well-resourced venture capital industry, and the extensive networks associated with successful clusters. Research and industry were poorly connected, hampering interactive learning and entrepreneurial action. Finally, neither locale had previously attracted significant political or financial support for biotechnology cluster development. Accordingly, both nascent agglomerations were 'institutionally thin' at the outset of the study, marked by the absence of key organizations and institutions, a lack of a common vision, and few interactions (Zukauskaite et al, 2017).

Eleven years later, the Brisbane and Melbourne biotechnology sectors had transformed (See Appendix D and E). Both had achieved significant growth in research employment and expenditure, which was paralleled by growth in industry size and capitalisation (increase in organisational 'thickness'). However, here the similarities cease.

The Brisbane agglomeration was atomistic and fragmented, with research and industry remaining largely disconnected. Inter-community perceptions were often negative, reflecting distrust and competitive tensions, which impeded localised learning (Hibbert et al., 2010). Further, local actors were narrowly focused on their individual survival, and did not see the relevance or benefits of engaging locally. Accordingly, the agglomeration lacked a strongly institutionalised common agenda and identity (Staber, 2011; Hibbert et al., 2010). Cluster governance structures were evident; however, these reflected an unbalanced power of dominance, being centralised around the government and disproportionately influenced by the research community. Thus, although the developing biotechnology cluster in Brisbane was now more elaborated in terms of its institutional thickness, the 'effectiveness' (Zukauskaite et al, 2017) of this thickness was questionable.

In the Melbourne biotechnology agglomeration, in contrast, there was increasing formal and informal cooperation between academe and industry, and greater understanding of how they could work together. Further, while local actors were concerned with their own survival, they also saw the relevance and benefits of engaging collectively, indicating emergence of a shared identity and agenda. The developing cluster also reflected a more balanced power of dominance, with inclusive top-down and bottom-up governance structures. In Melbourne, then, there was comparatively more elaborated and effective institutional thickness. Next, we reveal why Brisbane and Melbourne's cluster development paths differed so dramatically, linking this to the distinctive practice of clustering developed in each locale.

The practice of clustering in Brisbane

Catalysing

In Brisbane, a combination of good fortune and astute recognition of political opportunity provided the initial impetus for clustering. The Queensland Labour Government, led by Premier Beattie, was elected in 1998. Beattie was focused on diversification of Queensland's *"rocks and crops"* economy. Adamant that Queensland had to "*do more than just be a hole in the ground"*, Beattie believed future economic growth meant "*we've got to use our brains, innovation, and the university sector is absolutely essential"* (QS06)[vii] . The university sector "*saw opportunity in the disposition that the Government had*" (QS04). Research leaders seized the chance to *"get Peter Beattie and the politicians onside"*, convincing them *"that biotech was a fast-developing sector in the world economy, and that Queensland had a role to play in that"* (QS07). Biotechnology was framed as a means to shift Queensland's economic path:

> *"We need to recognise that past trends are not future destiny. The fact that historically Queensland has been a quarry and a farm and exploited by capital interests south of the border and overseas is not something that we need endure forever, and indeed the whole argument for developing a biotechnology industry is to dig ourselves out of that hole in which we have been for most of our history."* (SP006)

Serendipitously, the government's embrace of biotechnology was accompanied by arrival of the billionaire philanthropist Chuck Feeney. Feeney was introduced to leading researchers in Brisbane, and these individuals stoked Feeney's interest in supporting local research via his foundation, Atlantic Philanthropies. The government's economic vision also appealed to Feeney, and led to Atlantic Philanthropies becoming a major financial supporter and 'animateur' of local life sciences. Over the next decade, the tripartite relationship established between research-government-philanthropy was repeatedly leveraged to catalyse collective action for biotechnology development.

Coordinating

Collective action relied on top-down coordinating, which saw centralization of authority, planning, and decision-making around the Queensland Government: *"it has been very much government led in terms of setting direction and funding in biotechnology" (Int.#4, Gov).* Coordinating was achieved in three main ways.

First, the government was a major instigator or sponsor of events and activities enabling joint reflection about the local context for biotechnology. For example, 1998-2004 saw numerous events (e.g. a series of "BioFutures" conferences and quarterly 'BioLink' breakfasts) that connected local actors, and served as arenas where collective discussion and debate on their shared future could take place[viii]. Discussions were informed by production of papers and reports on local research and industry (e.g. the bi-annual Queensland BioIndustries report published from 1999 onwards) and deliberate efforts to learn from global success stories (e.g. through desk-top research and government-led 'missions' to leading international biotechnology centres). Together, these events and activities led to the emergence of three main discourses about the local biotechnology sector: 1) while there was a pre-existing research base, it was academic in orientation and poorly-connected to industry; 2) the existing industry was very small, lacking in essential resources (talent, finance), and constrained by a culture hostile to innovation; 3) and Brisbane was not recognised as a centre of biotechnology excellence.

Second, as a powerful actor, the government led efforts to create artefacts aligning the interests and efforts of local actors. It produced a series of biotechnology strategies (e.g. The 'Queensland BioIndustries Strategy" (1999); "The Queensland BioIndustries Strategy: 2000 and Beyond" (2002); "Biotechnology: Setting New Horizons 2005-2015 (2005)) that made explicit the actions and investments believed necessary for the *"industry to reach its projections of $4 billion in revenues and employing more than 16,000 Queenslanders by 2025"* (GOV022). The targets, actions, and key performance indicators articulated in these strategies

had a cumulative effect (Jarzabkowski, 2008; Sydow et al, 2010), reinforcing a particular trajectory of investment and intervention over time (see 'Configuring' for details).

Finally, the government instituted new cluster governance structures. Key examples included the Queensland Biotechnology Advisory Council (QBAC), and the Office of Biotechnology (OB). Created in 2000, QBAC was a committee of 10-12 high profile leaders from research, industry, and finance who acted as a sounding board for biotechnology strategy. By 2008, QBAC had expanded to include nine additional working groups and sub-committees. The OB, on the other hand, was a specialized government agency launched in 2005 that coordinated whole of government strategy development and delivery, and spearheaded marketing and promotional efforts.

By 2009, these coordinating activities, artefacts, and governance structures had the (unintended) consequence of perpetuating sharp tensions between the research and industry communities. Industry actors claimed the research sector wielded a disproportionate influence on the cluster's direction (*"…the research sector is so dominant that it's a research driven industry"* (P#16, Industry)), while the top-down governance structures inadvertently disenfranchised some stakeholders:

> *"But this causes conflict in the industry because some people say, 'well this is a closed club this advisory council". And they work together on a secret strategy and we can't – 'what is going on there?"* (P#12, Research)

Configuring

Interventions to support biotechnology over 1998-2009 reflected three broad themes: 1) 'From bricks to brains', 2) 'From brains to business', and 3) 'Selling Smart State'.

1.'Bricks to Brains': A major assumption driving configuring was that *"research institutions provide the basis for the development of the biotechnology industry"* (GOV005). From 1998 to 2009, more than $1.2B was expended on new research infrastructure, attracting

talent, and funding research activity (GOV058). The government-research-philanthropy partnership was pivotal here, underpinning a repeated pattern whereby Atlantic Philanthropies made large donations to local research organisations, which were then leveraged to secure matched funding from the Queensland and Australian Governments.

2. 'Brains to Business': A second assumption was that *"the research sector must link closely with a vibrant commercial sector"* (GOV003). The government encouraged this by providing incentives for applied research and industry interaction (e.g. creating funding schemes offering matched funding for research with industry) and embedding commercialisation obligations in infrastructure funding agreements (e.g. requiring formal business plans for IP management, making recurrent funding contingent on KPIs like *"the creation of a minimum of one spin off company per year for ten years"* (GOV165). It also addressed barriers including scarce commercial expertise, insufficient infrastructure, and a shortage of capital by investing in commercialisation training and education, constructing technology incubators, and working with the venture capital industry to create new biotechnology-focused investment funds.

3. 'Selling Smart State': Over 1998-2009, a high-profile marketing campaign sought to rebrand Queensland as the "Smart State", and saw significant internal and external promotion of biotechnology. Here, government publications served a dual purpose; artefacts of rhetoric as much as coordination, they were deployed to legitimate ongoing initiatives and investments, and to trumpet the many 'successes' already evident. Additionally, Premier Beattie and senior government officials personally participated in promotional efforts, which had significant symbolic value. For example, from 1998 till 2007, the Premier led annual delegations of the Brisbane cluster to major international biotechnology conferences, working hard to *"...drum up our reputation*" (Int#10, Finance). Beattie was so successful at this it provoked rivalry with other states:

"…overseas he [Beattie] was so good at selling Queensland anyone would think that the whole of the biotechnology industry in Australia was based in Queensland." (Int.# I, Melbourne)

By 2009, these activities had a pronounced effect on Brisbane's reputation:

"Queensland was not seen as the place you would do stuff ten years ago. Quite clearly that has changed dramatically by every pundit's observation." (P#19, Industry)

Deliberating

Reflexive deliberation drove catalysing, coordinating, and configuring in Brisbane. It enabled local researchers to recognise the opportunities inherent in a reforming State Government and a deep-pocketed philanthropist. It animated debates about the regional context, fostering insights about the potential of the research sector, the impediments to commercialisation, and the barriers posed by Brisbane's lacklustre reputation. These deliberative interpretations then drove specific collective actions to reinforce strengths and counter liabilities. Hence configuring emphasized substantial investment in the research base, embedding incentives and obligations to exploit research outcomes, and the provision of resources and skills for commercialisation. Interestingly, the deliberative logic reflected in these interpretations and actions aligns closely with a 'linear' approach to innovation support (Rosiello & Orsenigo, 2008; Magro & Wilson, 2013): that is, it presumes investments in basic research will almost automatically drive the development of biotechnology products and services (a 'science-push' philosophy).

The practice of clustering in Melbourne

Catalysing

In Melbourne, catalysing was led by a civic association, the Committee for Melbourne ("The Committee). Formed in 1985, the Committee is an apolitical, not-for-profit network of civic

leaders from business, academe, not-for-profit, and the arts dedicated to enhancing *"Melbourne's economic, social, and environmental future"* (IND027). In 1997, the Committee launched 'Thinking Melbourne', an economic development agenda predicated on the idea that *"we were going to have to use our smarts in the future"* (R1#1). Biotechnology cluster development was framed as key to this future:

> *"Biotech industries generate high and growing economic and human value. Melbourne has developed a world-class research cluster. Such a cluster is vulnerable without a critical mass of biotech companies at its core. We propose to kick-start the development of that critical mass. Failure to act now will not just be a missed opportunity; we risk losing our existing position"* (PPT003)

The Committee leveraged its longstanding relationships with local and state governments to lobby for support. In lobbying, it made explicit reference to Queensland's recent embrace of biotechnology:

> *"So essentially the Committee for Melbourne reignited State Government interest in biotech. The civic leaders actually said, 'hey, we're the traditional home of life sciences. Look at what Peter Beattie is doing"* (RI#3).

The Committee's efforts were successful, and catalysed concerted efforts across government, research, and industry over the next eleven years to foster cluster development.

Coordinating

In Melbourne, coordinating was top-down and bottom-up. Grass-roots coordination was facilitated through events, reports, and organizing structures instigated by the Committee, and then reinforced by sustained Victorian Government support.

In 1998, the Committee released a report examining Melbourne's biotechnology capabilities that found *"an obstacle to the future growth of the industry is the lack of extensive*

and integrated networks linking researchers with the business and financial sectors" (IND009). The Committee created a working group to connect local actors and coordinate efforts to overcome these issues. The working group, in turn, led to the 2003 launch of the BioMelbourne Network (BMN), an independent industry association modelled on successful associations from the United States. By 2009, BMN had become *"an important part of providing a focal point, and co-ordination point for the sector*" (P#V, Research). It developed a program of regular events and reporting activities, enabling joint reflection about current circumstances and future ambitions, and led bottom-up lobbying and cluster intervention.

The Victorian Government complemented these bottom-up efforts. Similar to the Queensland Government, it launched a major innovation policy (its Science, Technology and Innovation policy) in which biotechnology was prominent. It also produced a series of biotechnology strategies and reports, updated every three years. These coordinating artefacts made explicit the targets, actions, and key performance indicators intended to make Melbourne *"one of the world's top five biotechnology locations"* by 2010 (GOV067; GOV087; GOV103) and, as in Brisbane, these artefacts reinforced a particular trajectory of intervention and investment action (see 'Configuring' for details).

By the late 2000s, the BMN and Victorian Government increasingly collaborated in strategy development and implementation. For instance, in 2007 four working groups were formed to advise on relevant issues and explore new ideas for action, with these groups jointly coordinated by government, the BMN, and AusBiotech (the national biotechnology industry association).

Configuring

From 1998-2009, strategic intervention reflected three broad themes: '*Reinforcing the (scientific) foundations', 'Supporting commercialisation, and 'Building connectivity and*

cohesion'.

1. Reinforcing the (scientific) foundations: Over 1998-2009, the Victorian Government expended $722M on biotechnology, with 90% of this directed to research infrastructure, skills, and basic R&D (GOV118). A striking feature of this expenditure was deliberate efforts to foster cooperation amongst local research organisations. For example, the government invested in cooperative research consortium; these consortia involved collective governance and marketing, shared access to infrastructure and platform technologies, and encouragement of industry linkages and translational research. Another tactic was creation of 'precincts' co-locating research and education organisations, teaching hospitals, and (sometimes) industry. The development of these precincts was *"in part good fortune and in part deliberate*" (RI#3): often, they had emerged organically, but were then subject to concerted cultivation. By 2009, these strategies had embedded a "*willingness to co-operate"* (P#XI, Academic) amongst local research organisations.

2. Supporting commercialisation: First, when it came to supporting commercialisation, the Victorian Government favoured an indirect approach focused on building *"skills and capabilities rather than providing finance"* (GOV095). Notable initiatives here included the Technology Commercialisation Program, whereby private sector service providers received grants to provide management assistance and market support to local firms. Second, access to venture capital was viewed as major problem. In 2005, a BMN report identified obstacles to VC investment, including historically low returns, a lack of experienced management, and a lack of skilled analysts (IND015). These findings were used to lobby the Victorian Government for action, and led to the proposal that funding for certain government programs be redirected into incentives for superannuation funds to invest in biotech-focused venture capital firms (PC022). However, this proposal *"revived uncomfortable memories of the Victorian Economic Development Corporation, the ill-fated exercise in state funding of risky business ventures in*

the late 1980s that contributed to Labor's crushing electoral defeat in 1992" (PC023). The proposal was ultimately rejected.

3. Promoting connectivity and cohesion: As highlighted previously, in 2001 the Committee established the BMN to act as a 'bridge' between research, industry, and finance. The Committee incubated the network for two years, enabling clarification of its form and function, and mobilisation of resources from the City of Melbourne and the Victorian Government for its development.

The BMN officially launched in 2003, offering three services: "*influencing the industry development agenda; opportunities for business development and promotion; and providing business cost savings"* (IND009). Through this, the BMN intended to facilitate *"attitude and environment-changing"* and *"create learning opportunities at the peer-level"* (RI#2). Both research and industry were initially sceptical about the BMN's benefits. To overcome this, the BMN built legitimacy by targeting influential research and industry leaders for membership, and through developing a program of relevant and significant events. These tactics were largely successful. By 2007, the BMN's membership exceeded 170 members. With membership growth came enhanced political influence: *"we became more the voice of Victorian thinking"* (RI#2). This, in turn, enabled the BMN to play a larger role in industry advocacy and policy development, as well as in the marketing of the cluster.

Deliberating

Finally, deliberating energised catalysing, coordinating, and configuring in Melbourne. It underpinned the capacity of a local civic association to mobilise collective action by framing this as crucial to maintaining and building on Melbourne's reputation as the home of Australian life sciences. Deliberating also fuelled debates about the local biotechnology context, facilitating emergence of the widely shared belief that while Melbourne was home to well-

developed research capacity, a lack of connection between research and industry, and a deficit of venture capital were constraining growth. These interpretations then drove collective action to reconfigure how the research, industry, and financial sectors were organized and connected. Interestingly, these interpretations and strategic actions reflect a different deliberative logic to that observed in Brisbane. In Melbourne a more 'systemic' logic was evident; here, cluster development is not seen as an inevitable outcome of research investment, but rather as the more complex result of how different agents cooperate and learn (Rosiello & Orsenigo, 2008; Magro & Wilson, 2013).

Comparing the practice of clustering in Brisbane and Melbourne

Table 1 depicts Brisbane and Melbourne's main similarities and differences. By comparing how clustering activities unfolded across each case, we discerned two distinct shared understandings of the practice of clustering. These differences in shared understanding organized the core activities of catalysing-coordinating-configuring-deliberating into a specific practice of clustering that produced and reproduced the Brisbane and the Melbourne clusters in distinctly different ways.

In Brisbane, regional actors developed a shared vision of a biotechnology industry generating "*$4 billion in revenues and employing more than 16,000 Queenslanders by 2025"*. The collective understanding developed as to how to work together in achieving this is best described as *'building a pipeline'*: here, it is assumed that cluster development requires a pipeline from research to industry, and is enabled by 'supporting the source', 'plugging gaps' and 'removing blockages'. This understanding drove (and was reflected in) a particular way of enacting the core clustering activities. For instance, deliberating reflected a 'linear' logic which drove establishment of centralized, top-down coordinating structures and configuring that emphasized substantial investment in the research base (supporting the source), embedding incentives and obligations to exploit research outcomes (removing blockages), and intervention

to provide crucial resources and skills for commercialization (plugging gaps). While this significantly enhanced the cluster's material infrastructure, it was less successful in improving its relational infrastructure. Local actors did not always see the relevance of the cluster for interaction, engagement, and learning. Moreover, sharp tensions between research and industry indicated a failure to socialize local actors into "the common values and social identities of the broader cluster" (Hibbert et al., 2010: 14).

In Melbourne, regional actors developed a shared vision of creating *"one of the world's top five biotechnology locations"* by 2010. The collective understanding developed as to how to achieve this is best described as '*building an ecosystem'*, as it assumed that cluster development requires integration of local actors into a cooperative and collaborative ecosystem. Accordingly, deliberating reflected a more systemic logic, coordinating relied on more inclusive top-down and bottom-up governance structures and activities, and configuring targeted both the material and relational infrastructure of the cluster. Such interventions helped build effective 'institutional thickness' in Melbourne; by 2009, the cluster was widely recognized as an important site for interaction, engagement and learning, there was increasing linkage between research and industry, and evidence of a common identity and agenda. Taken together, it appears that Melbourne's specific practice of clustering was producing and reproducing a more sustainable and successful cluster than the one produced and reproduced by Brisbane's specific practice of clustering.

Table 1: Comparing the practice of clustering in Brisbane and Melbourne

Brisbane – Clustering as 'building a pipeline'	Melbourne – Clustering as 'building an ecosystem'
"So this is a pipeline, if you want good water pressure at the tap, at your house – so that's the market – you've got to go back along the pipeline and have a look at the dam, and you want to see a really, really, really big pipe there. Because by the time the water comes out of the dam and makes it to your house tap, the pipes get smaller and smaller, but you need that pressure behind it, pushing stuff through. So the pipeline analogy is actually quite relevant in this industry in that there is nothing wrong with having a heavy investment in that early end." (P#19, Gov)	"There is a spirit here which is 'we will work together'. So we've actively worked on that notion. We are not the only people in this space; the government has recognised that as well. Each organisation says, 'how do we collaborate together?' So the government has put in place the STI initiative, and the premise of that was, the government would fund some academic infrastructure, but it had to be shared by people within the precinct. So the synchrotron at Monash was government funded infrastructure to be shared. The Bio21 institute has a NMR machine that everybody has access to. So it enforces the collaboration, and it becomes less abstract because there is a reality around it." (P#2, Industry)
<u>Catalysing</u> • Triggered in response to serendipitous events • Driven by relationship between research-industry-philanthropy • Framed as a break from past: moving beyond Queensland's 'rocks and crops' economy	<u>Catalysing</u> • Triggered in response to Queensland Government's investment in biotechnology • Driven by a local civic association that later mobilised government support • Framed as continuous with the past: Melbourne is Australia's traditional home of life sciences
<u>Coordinating</u> • Collective reflection drives consensus that investment in the research base, removing obstacles to commercialisation, and cluster marketing are key to bioindustry development • Institution and elaboration of top-down governance structures	<u>Coordinating</u> • Collective reflection drives consensus that improving relations across academe and industry, and improving access to venture capital are key to cluster development • Institution and elaboration of top-down and bottom-up cluster governance structures
<u>Configuring</u> • Strategic intervention and investment reflect three broad themes: 'From bricks to brains', 'From brains to business', and 'Promoting Smart State'	<u>Configuring</u> • Strategic intervention and investment reflect three broad themes: 'Reinforcing the (scientific) foundations', 'Supporting commercialisation', and 'Promoting connectivity and cohesion'
<u>Deliberating</u> • Deliberating reflects a 'linear' logic of collective interpretation and action	<u>Deliberating</u> • Deliberating reflects a 'systemic' logic of collective interpretation and action

DISCUSSION AND CONTRIBUTIONS

The question of how clusters first emerge has long occupied regional scholars and policy makers. In this paper, we investigated how the exercise of system-level agency by regional actors contributes to cluster emergence. We applied a practice perspective to conceptualise system-level agency as enacted by regional actors through the *practice of clustering*, enabling sensitivity to its multi-actor, multi-scalar, and institutionally-structured character. By studying two nascent agglomerations, we found that the practice of clustering is constituted by four key activities - catalysing, coordinating, configuring, and deliberating. These activities are organized and integrated by development of a shared understanding of a) a future cluster vision and b) how to work and act together in achieving this. We found that the practice of clustering varies across locales, and that its outcomes – both intended and unintended – contributes to variation in the path creation processes giving rise to clusters. Significantly, some ways of clustering appear to better facilitate cluster emergence than others. Accordingly, our findings suggest that the specific practice of clustering that takes root in a given region can help explain why some nascent agglomerations develop into a functioning and viable cluster, while others do not.

Our account of how the practice of clustering facilitates cluster emergence makes four main contributions. First, research to date has explained cluster emergence through the presence of initiating factors, entrepreneurship, networks, and regional-embeddedness (e.g. path dependency and related variety). While not denying the significance of these features of cluster emergence, our findings highlight aspects presently underappreciated, most notably how regional actors connect initiating factors, entrepreneurial activities, network development, and regional assets to drive cluster emergence through their practice of clustering.

By showing how cluster emergence is facilitated through the practice of clustering, our model reveals that reflexive regional actors can ‘mindfully deviate’ (Garud & Karnoe, 2013)

from established regional paths and engage in concerted efforts to build, develop, and maintain a cluster. Through their ongoing performance of catalysing, coordinating, configuring, and deliberating, reflexive regional actors are able to connect chance events (e.g. arrival of philanthropist; exposure to cluster ideas from other locales) with existing regional assets (e.g. established scientific reputation and expertise) to develop a more or less shared vision and strategy for the future (e.g. a thriving biotechnology cluster). This vision then underpins regional actors' collective efforts to reconfigure the local context to better enable the entrepreneurial activities, network development processes, and regional resources required to achieve cluster development.

As a consequence of clarifying how the practice of clustering contributes to cluster emergence, our model is also able to better explain variation in cluster development paths. For example, Brisbane's specific practice of clustering substantially strengthened the reputation and capacity of the local research base, but was unable to effectively link the research and commercial communities together. In contrast, Melbourne's specific practice of clustering both reinforced its research capabilities and gradually instituted norms and values conducive to cooperation and collaboration both within and across the academic, industry, and financial communities.

Importantly, our model also clarifies *why* the practice of clustering can differ across regions. The model suggests that it is regional actors' particular shared understanding of cluster development that gives rise to variation in their practice of clustering. For example, in Melbourne, regional actors' shared understanding of 'building an ecosystem' led to a more effective practice of clustering than Brisbane actors' shared understanding of clustering as 'building a pipeline'.

Taken together, our study findings and model of the practice of clustering enables new ways of theorizing about how clusters emerge, grow, and change. It complements the prevailing

evolutionary line of thinking on clusters which largely "renders social agency, motivation, and strategy largely invisible" (Steen, 2016:1606). Our model of the practice of clustering yields potential for ongoing research on cluster emergence to make space for system-level agency alongside firm-level agency, and to be as sensitive to imagined cluster futures as it is to the legacies of a region's past.

Second, we contribute to the literature on new path creation (MacKinnon et al, 2019; Hassink et al, 2019) by offering a more fine-grained and integrative account of the various actors, activities, collective understandings, rules, and resources implicated in the exercise of system-level agency. We identified that practice of clustering often originates from the spontaneous, highly personal, and intuitive agency of individuals who mobilise others around opportunities and issues of common interest. This is consistent with previous work pointing to, for example, the significance of institutional entrepreneurs in cluster emergence (Ritvala & Kleymann, 2012). However, we further identified that as clustering practices take root, the incoherent 'patchwork' of individual interventions and actions gives way to a more or less shared cluster concept and logic for action, with this perpetuated and stabilised via mechanisms such as regular networking events (i.e. forums for collective engagement and reflection), the development of plans, strategies, and reporting activities (i.e. coordinating devices), and the institution of formal governance structures (i.e. working groups, committees, cluster associations).

These findings suggest two interconnected lines of future research on path creation. The first focuses on the role of learning. Both Melbourne and Brisbane were initially characterised by a marked absence of a shared cluster concept and logic for its development. Instead, this was developed over several years via a reflexive and collective learning process. This learning process relied on changes in ideas and knowledge sparked by exposure to cluster initiatives and policies from across the globe (e.g. through desktop research, observation of

regional rivals, international cluster/policy 'tourism', and inward migration of institutional entrepreneurs), and through contextualisation of such insights to interpret local circumstances and ongoing cluster outcomes. It would be interesting to examine more thoroughly the external reference points and sources of inspiration salient for path development, and to examine how these shape collective aspiration levels and interpretations of cluster performance over time (Argote & Greve, 2007).

Additionally, and linked to the above, in Brisbane and Melbourne certain understandings gained dominant positions as a lens for interpreting and acting on cluster issues (e.g. pipeline vs ecosystem). This suggests a need to investigate the political processes through which one imagined future and logic for achieving it comes to prevail over alternatives, and what the implications of this are in the long run (e.g. in Brisbane the coalition between academe and government was critical to the rise of the pipeline logic, but eventually and quite unintentionally led to tensions/rivalry between academe and industry). Following Lagendijk (2001) and Kiese (2010), this could involve studying shifting 'discourse coalitions', examining a) how concepts are mobilised because they play into the hands of regional actors with specific interests and ambitions, and b) how after being exposed to new discourses and new actors, regional actors may redefine what is at stake regarding specific cluster development issues.

Third, our findings contribute to the literature on the institutionalisation of clusters, deepening our knowledge of how nascent agglomerations develop the 'institutional thickness' intrinsic to interactive learning and collective action (Zukauskaite et al, 2017). We found that the practice of clustering contributed to the diversity of organisations within the cluster (organisational thickness), built networks (interactions), created coordinating artefacts and governance structures (structures of domination), and developed a shared understanding the cluster's purpose, membership, and ways of working together (mutual awareness and common agenda). We also found that the specific way clustering is practiced affects the relative quality

or ‘effectiveness’ (Zukauskaite et al, 2017) of institutional thickness produced. Relatively ‘poorer’ institutional thickness resulted from the establishment of centralised, top-down governance structures that disenfranchised certain actors, and the inculcation of a shared cluster concept that (inadvertently) perpetuated sharp divides between different communities. Comparatively ‘richer’ institutional thickness resulted from establishment of more inclusive, top-down and bottom-up governance structures, and development of a shared understanding of clustering that connected different communities and enabled their socialisation into the common values, purposes and agenda of the cluster. Building on this, future research can investigate how the practice of clustering contributes to ongoing cluster evolution. This could entail studying why some clusters are persistently more successful than others (e.g. how does the practice of clustering work in canonically successful clusters such as Silicon Valley?) and how cluster success is maintained or lost over time (e.g. how does the practice of clustering feed into cluster adaption and renewal, or to cluster ‘lock in’ and decline?).

Fourth, our findings contribute to the dialogue between economic geography and strategic management. Recent work has shed new light on how geography shapes the strategic decisions of firms (Knight & Wójcik, 2017). Here we show how multiple regional actors working across organisational boundaries can develop and enact strategy to enhance the competitiveness of clusters and regions. For strategic management scholars, our study demonstrates that attentiveness to clusters and their dynamics may be a fruitful new context for theorising how strategising unfolds in highly pluralistic settings (Jarzabkowski & Fenton, 2006; Denis, Langley & Roleau, 2007). Similarly, our findings about the different loci from which strategising in clusters develops (i.e. top-down, centrally-led processes vs. more autonomous, bottom-up processes) suggests clusters could also be an insightful context for understanding different manifestations of strategy (e.g. deliberate, emergent, ephemeral: see,

Mirabeau, Maguire, & Hardy, 2018), and their consequences for the competitiveness of firms, clusters, and regions.

Practically, our study suggests that regional actors can help transform budding agglomerations into fully-fledged clusters by deliberately cultivating an effective practice of clustering. For example, this could involve creation of spaces and forums enabling regional actors to jointly problematize how to work and act as a cluster, and to explicitly consider how existing norms, shared understandings and the local endowment of resources enables/constrains cluster development. It could also involve establishing inclusive bottom-up and top-down means of mobilising and governing clustering practice.

Finally, we studied the development of two nascent Australian biotechnology agglomerations. However, the practice of clustering will likely vary across developmental stage, and in different industries and regions, suggesting this is an important area for future research. Our study also relied an 11-year, historical case design and a correspondingly broad-ranged temporal bracketing analytical strategy. An ethnographic approach (e.g. Berthod et al, 2017) and a more fine-grained temporal bracketing strategy could deepen and extend our understanding the practice of clustering by revealing its everyday performance by regional actors.

CONCLUSION

Industry clusters are a prevalent feature of the contemporary economy, and have attracted significant policy and academic interest. Despite fervent uptake of cluster thinking, many uncertainties remain about how clusters emerge, develop and grow, and how the design and implementation of cluster policy can be improved. Through our analysis of two nascent biotechnology clusters, we found that the 'practice of clustering' is pivotal for transcending the pernicious material and social conditions of characteristic of nascent agglomerations. Without

developing and institutionalizing an effective practice of clustering, nascent agglomerations may struggle to transition from an atomised and weakly structured collection of proximate individuals and organizations into a functioning and viable cluster.

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[i] For example, due to supportive local conditions such as a strong research base, an entrepreneurial regional culture, or policy support.

[ii] Following Menzel & Fornahl (2010) 'interconnections' entail traded and untraded interdependencies like market exchange of goods and services, labour mobility, monitoring and imitation of behaviour, social networks, and face-to-face interaction and cooperation.

[iii] 'Non-firm' actors could entail individuals from government, universities, the venture capital sector, and intermediary organisations (e.g. industry bodies and associations).

[iv] For example, Menzel & Fornahl's (2010) influential cluster lifecycle model explicitly excludes consideration of how regional capabilities influence cluster dynamics as these entail "local characteristics that apply to all companies in the respective region". Other models, such as Feldman et al (2005), do mention the importance of regionally-embedded resources and institutions, but predominately focus on the role of entrepreneurship in cluster emergence.

[v] Human agency is rooted in the innate human capacity for desiring, for intentionality, and for creative action. It is the power to do. As Sewell (1992:20) observes: "To be an 'agent' means to be capable of exerting some degree of control over the social relations in which one is enmeshed, which in turn implies the ability to transform those social relations to some degree".

[vi] Brisbane is the capital city of the Australian state of Queensland, while Melbourne is the capital city of the Australian state of Victoria.

[vii] See Appendix F for citations for archival documents and historical interviews

[viii] Such events continued over 2005-2009 but declined in frequency (e.g. cessation of BioLink breakfasts; but institution of Annual CEO summit)

Appendix A: Breakdown of dataset

Archival documents (n= ~350)				
Genre	*Code*	*Number entered into registry*	*Approx. pages of text*	*Approx. pgs of text*
Annual Reports (firms, universities, hospitals)	AR001-AR014	14	369	~10,119 total pages
Conference materials	CM001-CM005	5	514	
Media releases	MR001-MR022	22	376	
Promotional brochures, reports, and directories	PR001-PR028	28	304	
Industry reports, publications and position papers	IND001-IND025	25	899	
Press clippings	PC001-PC027	27	82	
Government policy statements, reports, position papers, working group and committee papers, etc.	GOV001-GOV156	156	6285	
Transcriptions of public speeches and presentations	SP001-SP021	21	187	
Submissions to State & Federal Government Inquiries	GI001-GI037	37	647	
Newsletters	NL001-NL012	12	181	
Powerpoint presentations	PPT001-PPT014	14	275	

Oral histories & retrospective interviews (n= 11)			
	Code	*Duration*	*Approx. pgs of text*
Publicly available oral histories with former premiers, ministers, ministerial staffers, public servants, and university vice chancellors (www.queenslandspeaks.com.au)	QS01-QS08	Audio files range from 1 to 3 hours in duration. However, only transcribed relevant extracts (i.e. sections pertaining to biotechnology & Smart State)	~90 single-spaced pages of text
Retrospective interviews with key government, community and industry leaders on the Melbourne cluster's early history and development.	RI-RI03	Interviews ranged from 1h to 1h26min in duration. Audio files were transcribed in their entirety.	

Semi-structured interviews (n=45)					
Stakeholder Type	*Brisbane*	*Melbourne*	*Code*	*Duration*	*Approx. pgs of text*
Industry	8	5	Interviews #1-24 refer to Brisbane. Interviews #I-XXI refer to Melbourne.	Ranged from 30min to 1h25min in duration. Average duration ~48.9min.	~756 single-spaced pages of text
Academe	4	4			
Technology transfer (TT)	2	3			
Finance	3	3			
Service	3	3			
Government	4	2			
Industry Association	-	1			
Total approx. textual materials analysed: ~10,965 pages of text					

Appendix B: Data collection procedures

The dataset was assembled as follows. First, we built an extensive archive of documents tracing cluster development over 1998-2009. The archive incorporated industry reports, policy statements, strategic plans, promotional materials, press clippings, transcriptions of public speeches, conference presentations, submissions to government inquiries, newsletters, and statistical data (e.g. employment figures, research expenditure, surveys of research and commercialization performance). The archival materials were used to develop insight into the initiating conditions and key collective interventions undertaken to restructure the regional context to support cluster development.

Next, we deepened understanding of each cluster's origins and development by a) transcribing publicly available historical interviews exploring key biotechnology initiatives in Brisbane (n=8) and; b) by conducting historical interviews about the Melbourne cluster's early development (n=3). In both instances, interview participants were directly involved in the design and implementation key biotechnology initiatives, and the historical interviews were used to validate and elaborate insights from the archival materials.

Finally, in 2008 we conducted 45 semi-structured interviews in Brisbane and Melbourne in order to characterize the outcomes of the previous decades cluster development efforts. This included insights into cluster membership, performance, internal and external network connections, and opportunities for future development. Participants were leaders from the different 'societal spheres' (Giddens, 1984) of government, research, industry, and finance, and included CEOs and executives, research institute directors, and senior public servants.

Appendix C: Stages of Analysis

Stages	Tasks	Outputs
1. Global analysis	• Undertook a global analysis (Flick, 2018) to gain an overview of thematic range of our dataset. This included developing an archival registry that summarized each archival document, identified the time period to which it related, and listed central concepts and key words. Similarly, the historical and real-time interviews were subjected to an initial open-coding process to identify preliminary insights relevant to each cluster's development path. The archival documents and historical interviews were used to gain insight into the initiating conditions in each locale, as well as the collective interventions to reconstruct the regional context to support cluster emergence. The real-time interviews and contemporary documents were used to gain insight into the outcomes of these collective actions and interventions.	Global analysis enabled decomposition of the dataset into three rough and overlapping groups for further, analysis: the first group. 'Period 1, clarified the initial conditions in each region (1998-2001), the second 'Period 2' clarified actors' attempts to reshape the regional context to support cluster emergence, (1998-2007), and the third, 'Period 3', clarified the concluding cluster context (2008-2009).
2. Developing chronological case histories	• Developed a detailed narrative of each agglomeration's development over 1998-2009, characterising the initial conditions in each locale (Period 1), how local actors sought to restructure the regional context to better support cluster emergence (Period 2), and the character of the cluster at the conclusion of the study (Period 3).	A thick description of each nascent agglomeration's development path.
3. Identifying the core activities constituting the practice of clustering through a data reduction process	• Coded the thick descriptions of each agglomeration's development by developing descriptive empirical codes of what regional actors actually did to facilitate cluster emergence in each period, such as framing issues, connecting actors, mobilising resources, participating in events, producing reports and plans, providing funding, building infrastructure, communicating meanings, and so on. We then aggregated descriptive codes interpretively according to their character and purpose, enabling derivation of four core clustering activities. These were labelled according their empirical characteristics as *deliberating, catalysing, coordinating,* and *configuring*.	Four core activities identified to constitute the practice of clustering
4. Connecting initial conditions, clustering activities, and clustering outcomes	• Returned to the thick descriptions, focusing on Period 1 and Period 3, coding for evidence of 'institutional thickness', understood as shared cluster rules and resources shaping local actors (inter)actions at this time. • Returned to the thick description, focusing on Period 2, to further interrogate how the core clustering activities were performed in each cluster, specifying their triggers, the key actors involved, what changes/outcomes were sought, the specific interventions to achieve this, and the intended and unintended outcomes of these activities. • By drawing connections between the initial regional conditions (Period 1), the clustering activities (Period 2), and the outcomes of these activities (Period 3), we were able to identify how the core clustering activities produced and reproduced cluster rules and resources over time.	Established how system-level agency was exercised through clustering activities, and whether this created, reproduced or modified cluster rules and resources in different time periods.
5. Analyse cross-case practice of clustering	• Iterative comparison of clustering practices across Brisbane and Melbourne revealed similarities and differences, with these differences able to be attributed to a distinct shared understanding of clustering in each locale. We labelled different shared these understandings according to their empirical characteristics as 'building a pipeline' and 'building an ecosystem'.	Two different practices of clustering identified, underpinned by a distinct shared understanding of clustering.

Appendix D: Cluster development in Brisbane, 1998-2009

<table>
<tr><th>Dimension of Institutional Thickness</th><th>Initiating conditions
(Period 1: 1998-2001)</th><th>Concluding conditions
(Period 3: 2008-2009)</th></tr>
<tr><td>Organisational Thickness</td><td>Incomplete value chain: home to an existing research base, but a small industry base. Industry structure dominated by early stage biotechnology firms. Marked absence of large multinational pharma and biotechnology firms.

<table><tr><td>Main Industry Focus</td><td>Medical & agricultural biotechnology</td></tr><tr><td>Economic Size</td><td></td></tr><tr><td>Research Organisations</td><td></td></tr><tr><td>Total R&D $/annum</td><td>$175.2M</td></tr><tr><td>Employees</td><td>903</td></tr><tr><td>Biotechnology firms</td><td></td></tr><tr><td>Number of firms</td><td>19</td></tr><tr><td>Employees</td><td>186</td></tr><tr><td>Total Market capitalisation of listed firms</td><td>Data not available</td></tr></table></td><td>Incomplete value chain: substantial growth in both research and industry base, however, industry structure continues to be dominated by small start-ups with no large multinational pharma or biotechnology firms.

<table><tr><td>Main Industry Focus</td><td>Medical & agricultural biotechnology</td></tr><tr><td>Economic Size</td><td></td></tr><tr><td>Research Organisations</td><td></td></tr><tr><td>Total R&D $/annum</td><td>$465.1M</td></tr><tr><td>Employees</td><td>6169</td></tr><tr><td>Biotechnology firms</td><td></td></tr><tr><td>Number of firms</td><td>90</td></tr><tr><td>Employees</td><td>3760</td></tr><tr><td>Total market capitalisation of listed firms</td><td>$266.17M</td></tr></table></td></tr>
<tr><td>Interconnections</td><td>Little evidence of networks between regional actors within and across the academic, industry, and financial communities</td><td>Persistence of poor internal connectivity

- “But I think that a lot of companies sit there in isolation. I don’t know. Or they might have a tenuous network” (P#10, Finance)
- “We’re not all that connected…I mean we know some of the other organisations. I mean, we know of [Company A], I think I’ve met with a couple of their people once, at the airport I think” (P#5, Industry)
- “I think there were a lot of hopes and a vision of a lot more interactions than there probably is.” (P#6, Research)</td></tr>
<tr><td>Cluster Rules</td><td>No evidence of a collective cluster concept, nor shared understanding of cluster purpose, membership, and norms for working and acting together</td><td>Emergence of negative perceptions and competitive tensions across cluster communities (e.g. academe and industry) that constrain their ability to work together

- “Really biotech companies are never going to succeed. I think a lot of us view that as somewhat wasteful, and that money needs to be at the coalface, at discovery” (P#2, Research)
- “And there are plenty of bloody scientists in the community whose expectations of what they should get from research is just a long way from reality. And they’re just impossible to deal with”. (P#13, Industry)
- “I would say our culture is competing internally. For resources, space, people. Everything. Credibility. I think that is one of our weaknesses, there is too much competition.” (P#14, Research)</td></tr>
</table>

		Poorly developed sense of the collective and its relevance; lack of common agenda and identity - *"…you've got the research sector standing in one corner, you've got the commercial sector in another corner and the service providers running between the two trying to drum up business, rather than all feeling as though they are part of the one industry and they are all on the same team"* (P#16, Industry) - *"I think there is an unconscious clustering, they don't realise the benefits of getting together in cluster, because there is just so much shared learning that people could do, you know, without re-inventing the wheel."* (P#13, Industry)
Cluster Resources	**Scarcity or absence of key resources (e.g. financial capital, entrepreneurial skills and knowledge) recognised as crucial for biotechnology cluster development.** - *"Queensland has not developed the spin-off commerce and industry from its strong research capacity"* (IND003) - *"Queensland currently lacks extensive pools of entrepreneurs with the skills and experience to develop alliances, attract venture capital and bring advanced technology products to global markets."* (GOV005) **No evidence of cluster governance structures at study outset**	**Developing but insufficient supply of key resources (inc. capital and skills) recognised as critical for biotechnology cluster development.** - "*You know, we are learning how to invest, we are learning how to manage companies, support them, but there is still in all of those areas that support start-ups there is still a need for people. It's sort of like a vicious cycle between the money and the people. There are lots of little companies out there that would thrive if they had great management but they haven't got the money to employ great management even if it were available."* (P#15, Industry) **Development of top-down cluster governance structures centred on the Queensland government**

Source: GOV002; GOV059; GOV166; IND003

Appendix E: Cluster development in Melbourne, 1998-2009

<table>
<tr><th>Dimension of Institutional Thickness</th><th>Initiating conditions (Period 1: 1998-2001)</th><th>Concluding conditions (Period 3: 2008-2009)</th></tr>
<tr><td>Organisational Thickness</td><td>Incomplete value chain: home to an existing research base, but a small industry base. Industry structure dominated by early stage biotechnology firms. Marked absence of large multinational pharma and biotechnology firms.

<table><tr><td>Main Industry Focus</td><td>Medical & agricultural biotechnology</td></tr><tr><td>Economic Size</td><td></td></tr><tr><td>Research Organisations</td><td></td></tr><tr><td>R&D expenditure</td><td>$241.7M</td></tr><tr><td>Employees</td><td>2101</td></tr><tr><td>Biotechnology firms</td><td></td></tr><tr><td>Number of firms</td><td>63</td></tr><tr><td>Employees</td><td>Data not available</td></tr><tr><td>Total Market capitalisation of listed firms</td><td>Data not available</td></tr></table></td><td>Incomplete value chain: substantial growth in both research and industry base. While the industry structure still largely lacked large multination pharma or biotech (with the exception of CSL Ltd), there was evidence in maturation of a subset of firms (e.g. 7 firms now had market capitalisations in excess of $250 million).

<table><tr><td>Main Focus</td><td>Medical & agricultural biotech</td></tr><tr><td>Economic Size</td><td></td></tr><tr><td>Research Organisations</td><td></td></tr><tr><td>R&D expenditure</td><td>$870M</td></tr><tr><td>Employees</td><td>8406</td></tr><tr><td>Biotechnology firms</td><td></td></tr><tr><td>Number of firms</td><td>139</td></tr><tr><td>Employees</td><td>6950</td></tr><tr><td>Total Market capitalisation of listed firms</td><td>$22.7B[1]</td></tr></table></td></tr>
<tr><td>Interconnections</td><td>Little evidence of networks between regional actors within and across the academic, industry, and financial communities</td><td>Growing internal connectivity

- “Well everybody knows everybody. I think the networks are pretty, well it’s tight enough. And expansive enough”. (PX, Industry)
- “I know a lot of the guys from the different companies. All the biotech people, you get to know all of these guys. The same faces are often going to these events all the time.” (PVII)
- “If you go to any of these [cluster] precincts, they have the same characteristics of bringing people together.” (P II, Industry)</td></tr>
<tr><td>Cluster Rules</td><td>No evidence of a collective cluster concept, nor a shared understanding of cluster purpose, membership, and norms for working and acting together</td><td>Improving perceptions across communities and developing sense of how they work together

- “So I think that the universities and biotechnology companies have to work hand in hand” (P#I, Industry).
- “...we really want to take some responsibility for being advocates for ideas and developing them in conjunction with industry” (P#XIV, Research)</td></tr>
</table>

[1] The bulk of figure was driven by a single firm, CSL Limited, which had a market capitalisation of $19.2B at the end of 2009 (NL011)

		- *"And so we are all integrated because you can't do business development in this environment unless you understand the science that is going on in the place, and how that science impacts upon the government, commercial and, I guess, academic sector that you plug into all the time*" (P#XIII, Industry) **More developed sense of the collective and its relevance; emergence of common agenda and identity** - *"You don't feel like you're in an aggressive, ultra-competitive environment. I think there is a firm understanding of Melbourne's place in the world and that we all need to actually be on the same team to move forward."* (Int. #X, Academe) - *"I think clusters are important to chances of really developing an industry. Because you can't do it on your own. You need a lot of people with different layers of expertise to bounce ideas and results off other independent people to assess the quality and way forward*." (P# IX, Industry)
Cluster Resources	**Scarcity or absence of key resources (e.g. financial capital, entrepreneurial skills and knowledge) recognised as crucial for biotechnology cluster development.** - *"Melbourne has the intellectual base to be recognised as the premier hub in the Southern hemisphere for medical and agricultural biotechnology, but we currently lack the active coordination, local investment, and commercial knowledge to crystallise this vision in the short term"* (IND007) **No evidence of cluster governance structures at study outset**	**Developing but insufficient supply of key resources (inc. capital and skills) recognised as critical for biotechnology cluster development.** - *"So I think that what is really missing are folks who have really done it before. So they have actually gone through getting products registered. And there are a lot of folks who know a little part of the puzzle but are kind of learning as they go along.* (Interview XV, Finance**)** **Development of bottom-up and top-down cluster governance structures centred on an industry association and the Victorian Government, respectively.**

Sources: GOV166; IND003; GOV117; GOV110; GOV111

Appendix F: Archival Materials Citations

GOV002: *"Queensland Biotechnology Report 1999*" (1999), Ernst & Young for the Queensland Government.

GOV003: *"Queensland's Response to 'Developing Australia's Biotechnology Future'"* (1999), Queensland Government.

GOV005: *"Biotechnology in Queensland - Background Paper"* (2000), Queensland Government.

GOV022: "*Biotechnology - Setting New Horizons: Queensland Biotechnology Strategic Plan* 2005-2015" (2005), Queensland Government.

GOV059: "*Queensland Life Science Industry Report"* (2010), Queensland Government.

GOV067: *"Biotechnology Strategic Development Plan for Victoria"* (2001), Victorian Government.

GOV058: "*Queensland Science: The Tipping Point*" (2010), Annual report of the Queensland Chief Scientist, Queensland Government.

GOV087: "*Biotechnology strategic development plan for Victoria"* (2004), Victorian Government.

GOV095: *"Productivity commission study into public support for science and innovation"* (2006), Victorian Government.

GOV103: "*Action in partnership - Building our biotech future*. *Victorian biotechnology strategic development plan 2007"* (2007), Victorian Government.

GOV110: *"Victorian Biotechnology Industry Profile 2009"* (2009), Victorian Government.

GOV111: *"Victorian Biotechnology Strategic Development Plan 2007: Progress Report",* (2009), Victorian Government.

GOV117: *"Victorian biotechnology industry skills review"* (2010), Allen Consulting Group Pty Ltd for the Victorian Government.

GOV118: *"Biotechnology in Victoria: The Public Sector's Investment*" (2011), Report by Auditor General, Victorian Government.

GOV165: Question on notice 557, Tuesday 14 May 2002, Queensland Parliament, Hansard Record of Parliamentary Proceedings.

GOV166: Research & Experimental Development, Higher Education Organisations (2010), Australian Bureau of Statistics, Catalogue 8111.0. 2008, Statistics on higher education research expenditure (HERD) for the years 1992 to 2008.

IND003: *"BioBusiness Report: Queensland's Strengths and Challenges in the Life (Bio) Industries"* (2000), The Brisbane Institute.

IND007: *"Boston Biotechnology Report"* (2000), The City of Melbourne.

IND009: *"The BioMelbourne Network - Background Information* (2003), BioMelbourne Network.

IND015*: "Expansion Capital for Innovation Report"* (2005), Boston Consulting Group for the Committee for Melbourne.

IND027: *Committee for Melbourne* website (http://www.melbourne.org.au/cms-about-us/who-are-we-membership), 2013.

NL011: "Biotech Business Indicators (2004-2010)", Australian Government. (http://www.innovation.gov.au/INDUSTRY/BIOTECHNOLOGY/BIOTECHBUSINESSINDICATORS/Pages/default.aspx)

PC022: *"Biotechs push super funds investment"* (2005), Rebecca Urban, '*The Age'* (press clipping).

PC023: *"State cash plan for tech firms"* (2005), Rebecca Urban and David Elias, *'The Age'* (press clipping).

PPT003: *"Biotech Victoria: Presentation to Industry"* (1998), Committee for Melbourne. Powerpoint presentation of the findings of the Boston Consulting Group Report into Victoria's biotechnology industry.

QS04: *'Queensland Speaks' interview with Ross Rolfe*, Director General of the Department of State Development (1998-2002) and Director General of Premier and Cabinet (2005-2007). (https://queenslandspeaks.com.au/ross-rolfe)

QS06: *'Queensland Speaks' interview with Peter Beattie*, Queensland Premier 1998-2007. (https://queenslandspeaks.com.au/peter-beattie)

QS07: *'Queensland Speaks' interview with John Strano*, Senior member of the Queensland public service. (https://queenslandspeaks.com.au/john-strano)

R1#1: Retrospective interview with a former CEO of the Committee for Melbourne.

RI#2: Retrospective interview with a former CEO of the BioMelbourne Network.

RI#3: Retrospective interview with actor who has occupied high-level roles in both university and government.

SP006: Transcript of speech delivered at BioFutures Conference on Employment, Ethics & Commercialisation (27 October 1999, Brisbane).

References

Flick, U., 2018. An introduction to qualitative research. Sage Publications Limited.